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AirPolTool: A WEB-BASED TOOL FOR ISTANBUL AIR POLLUTION FORECASTING AND CONTROL

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ABSTRACT
A web-based tool AirPolTool for air pollution prediction and control in Istanbul is developed. It models the relationship between local meteorological data and air pollution indicators concentrations like SO_2, PM_{10} and CO by using neural networks. AirPolTool presents on the user-friendly website airpol.fatih.edu.tr three-days predictions of air pollution indicators and supports appropriate episode warning signals and the relevant actions to be taken by the government or the public to reduce that particular pollutant to non-harmful level.

Key Words: Air Pollutants, Prediction, Meteorology, Web Page Modeling

1. INTRODUCTION

Air pollution is one of the most important environmental problems in metropolitan cities like Istanbul. The spatial and temporal variations in emissions of air pollutants and the accompanying variability in meteorological conditions can lead to occurrences of pollutant levels, which can cause adverse short-term and chronic human health impacts (Künzli et al., 2005). Urban air quality management and information systems are required to predict of next day's air pollution levels and for providing proper actions and controlling strategies. Air quality warning systems are therefore needed in order to obtain accurate advance notice that ambient air concentration levels might exceed air quality guideline or limit values. Warnings can be utilized to alert health care as well as traffic and environmental management so that the adverse effects can be minimized. Such warning systems must be sufficiently reliable and understandable by the majority of people.

Currently the municipality of Istanbul has been monitoring nine permanent air pollutants at stations from from Istanbul parts Yenibosna to Kartal. A web based information system www.ibb.gov.tr/index.htm presents information about the current and the earlier periods of air pollution conditions in Istanbul. However there are not future predictions of air pollution situation of the city. This is not only a Turkish national gap but also a worldwide one including many developed countries which

have not such a system. There are few very limited examples in this area (cf. http://turkish.wunderground.com/US/NY/New_York.html).

In recent years, neural network models have been developed and applied to atmospheric pollution modeling in general (Gardner and Dorling, 1998) and air quality problems in particular (Gardner and Dorling, 1999a; Gardner and Dorling, 1999b).

In this study a web-based system *AirPolTool* implementing the neural networks-based air pollution prediction model NN-AirPol (Karaca et al., 2005) is developed.

The objectives of this tool can be summarized as follows:

1) Three-days prediction of air quality .

2) Creating of a user-friendly website which provides access to air quality forecasting information.

3) Supporting of episode warning and actions.

4) Supporting the best possible emission reduction scenario.

5) Reducing the cost of measuring air pollutants by modeling techniques

2. DESCRIPTION OF AirPolTooL

AirPolTooL has the following steps (cf. Figure 1). At the first step, for the air pollution data gathered, the best fitting backpropagation algorithm (BPNN) minimizing the error between neural network output and target value is selected. At step two, by for the concentration of air pollution indicators SO_2, PM_{10} and CO, the air pollution data for the next 3 days according to weather forecasting are determined. The prognoses of these concentration indicators present the outputs of the neural network (NN). For more details about air pollutants prediction see Karaca et al 2005. If the concentrations are higher than the threshold values (cf. Figure 1) relevant episode measures and strategic action plans are proposed. If the concentrations are dangerous for human health (> 300 mg/m^3 for SO_2 and PM_{10}, and >3000 $\mu g^{-3}$for CO) red ecowarnings and ecoactions are proposed. If the concentrations are higher than national air quality standards for certain areas (> 150 mg/m^3 for SO_2 and PM_{10}, and >1500 $\mu g^{-3}$for CO), yellow episode and strategic action plans are proposed. If the concentrations are lower, green episode and strategic action plans are proposed. A two-layer neural network with tan-sigmoid transfer function, a hidden layer and a linear transfer function at the output layer were used (cf. Figure 2). This NN has 7 input parameters and 3 output parameters (SO_2, PM_{10} and CO), which are essential for accurate modelling of the air pollution.

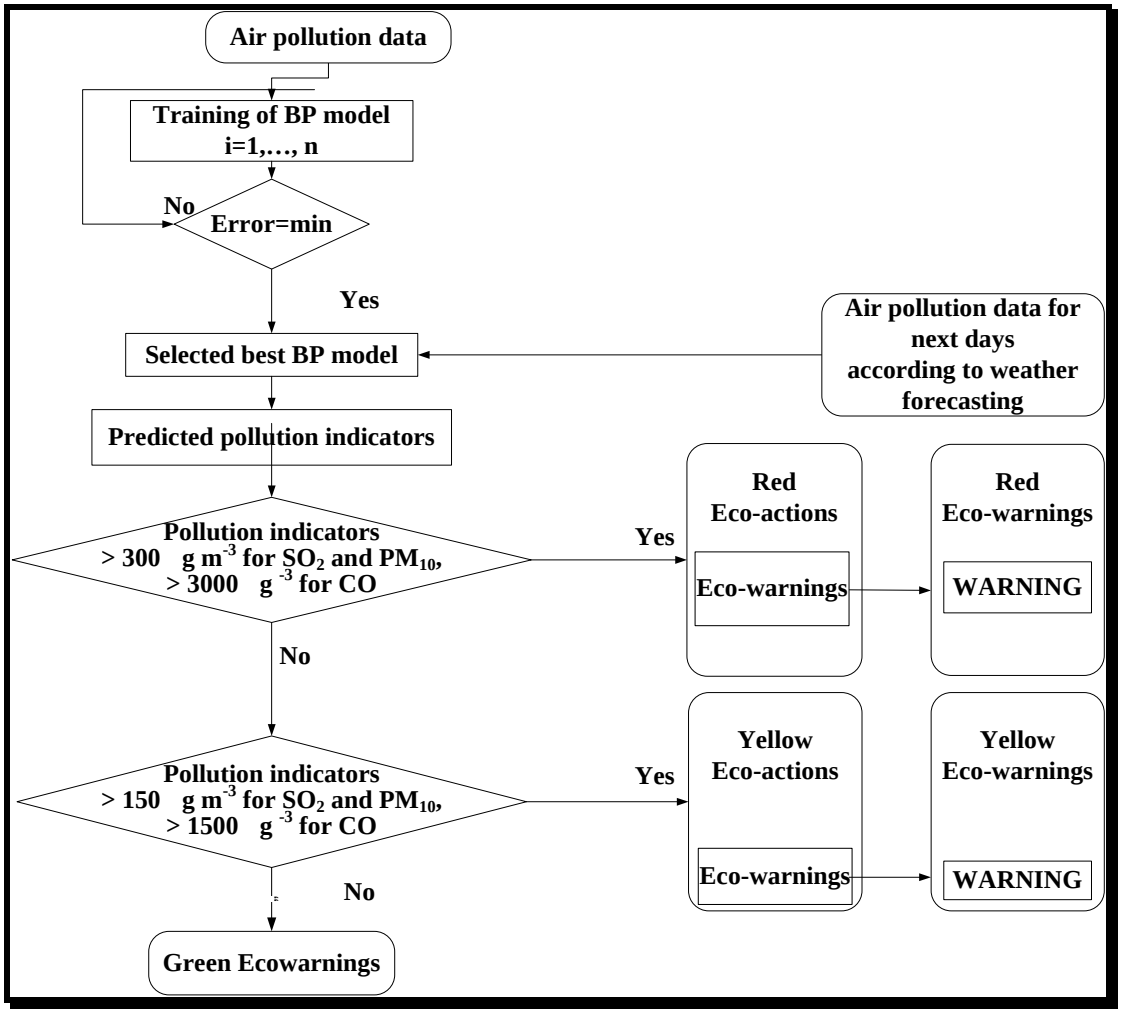

Figure 1. AirPolTool sequence of steps

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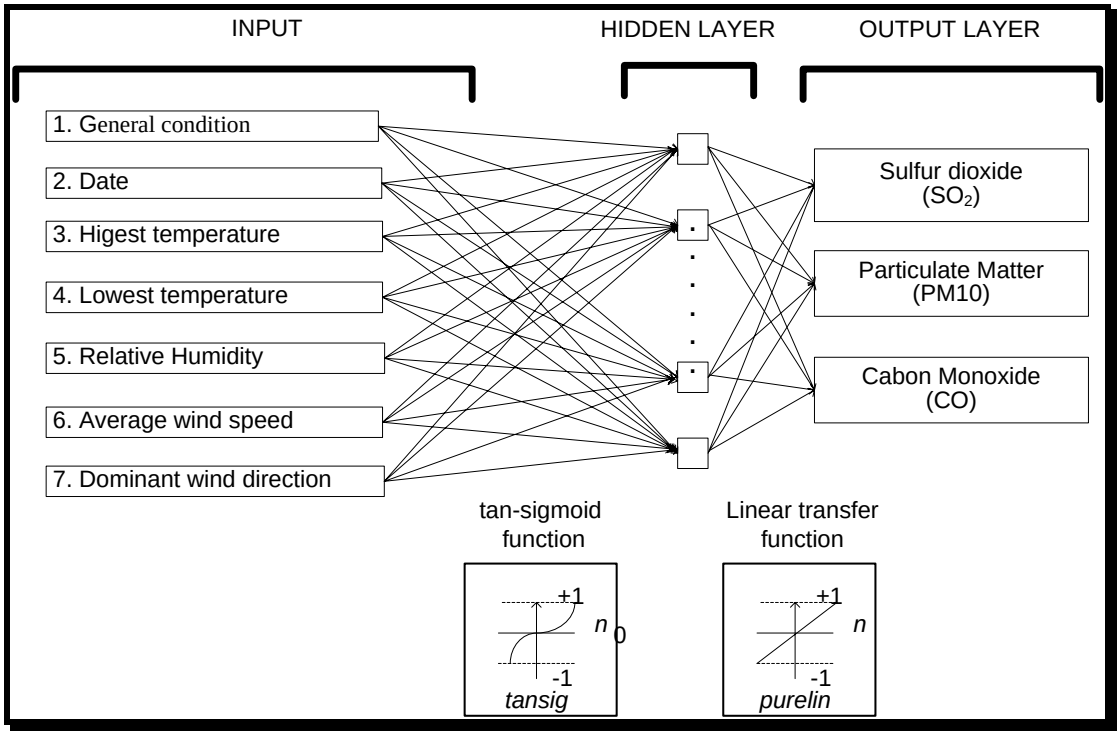

Figure 2. The neural network structure of AirPolTool

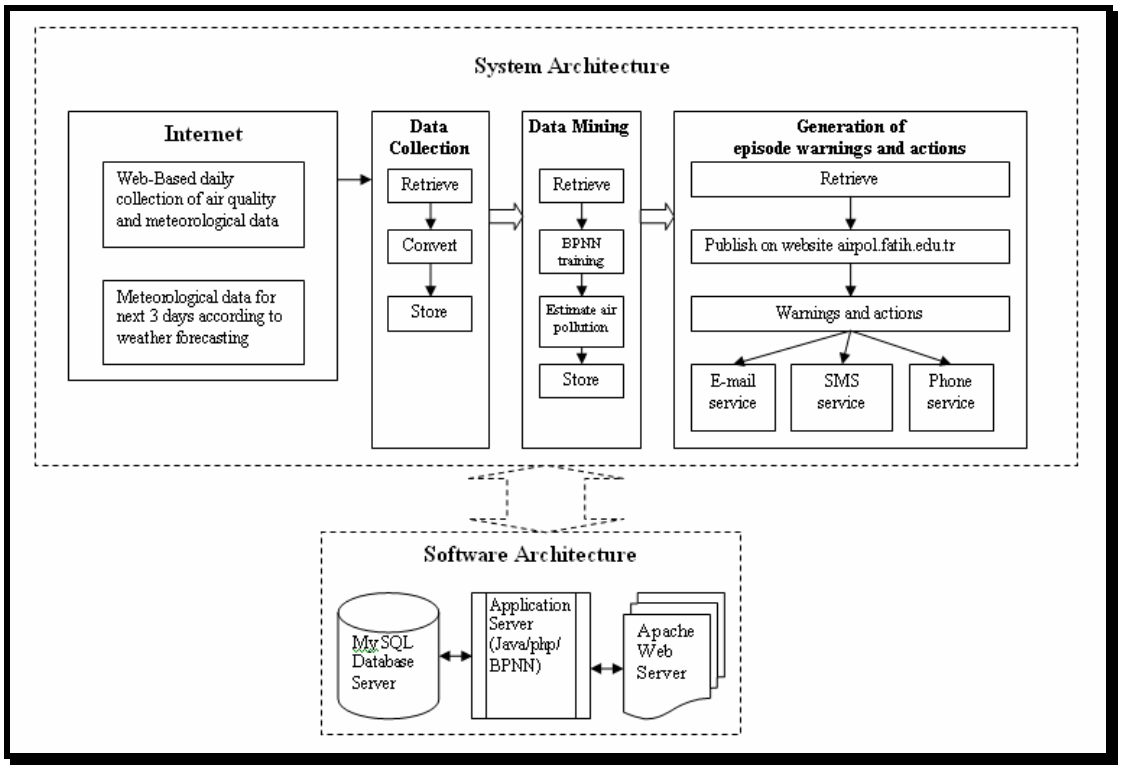

Figure 3. AirPolTool architecture

In the following the AirPolTool architecture shown on Figure 2 is explained.

2.1. Data Collection Module

The data collection module retrieves data from Internet, converts the data in html or xml (see EML, 2005) format to strings and stores the data in a MySQL database.

This module collects daily weather forecasting and air pollution data. Air pollution data are collected from www.ibb.gov.tr in html format. It is parsed by Java program and placed in a MYSQL database. Currently there are 7 weather forecast parameters (cg. Figure 3). These parameters are currently retrieved from www.bbc.co.uk/5day.shtml. Weather forecast parameters are retrieved by a program written in Java and placed in the database.

2.2. Data Mining Module

Data mining is performed on the collected data to predict air pollution levels for the next 3 days. This is done training a feed forward backpropagation neural network applying MATLAB script. Both data collection and data mining is performed daily with new day's forecast and pollution levels using a windows script that invokes application programs.

2.3. Data Presentation Module

The data presentation module consists of a dynamic web page created by application programs hosted in a web server. A screenshot of the main page is given in Figure 4. The page contains a map of Istanbul, today's weather forecast data and estimated pollutant levels in the form of a drawing. The web page currently provides air quality estimation for Istanbul part Yenibosna only, indicated by a bright spot on the map. However we will include other stations/locations in Istanbul in the future. The page displays pollutant levels as a graph. The warning and danger levels are indicated with yellow and red lines on the drawing.

2.4. Software Architecture

The software used in the AirPolTool consists of a database server (MySQL version 4 see MySQL, 2005), a web server (Apache version 2. see Apache, 2005), and application software written in Java (see Java, 2005), Php (see Php, 2005) and Matlab (see Matlab, 2005) scripting language.

The database consists of 2 tables: *DailyMeasurements, Estimates*. *DailyMeasurements* table stores daily weather forecast data and 3 pollutant levels. *Estimates* table holds 3-day estimated values of pollutant levels for each day in the *DailyMeasurements* table.

The web server is used for publishing the results as a web page. It invokes application programs (collectively called application server) that perform various tasks such as conversion, visualization, data mining, etc.

The application server consists of a set of programs for performing the tasks mentioned above. These programs retrieve data from the database server, perform the required tasks and store the result in the database.

3. DESCRIPTION OF AirPolTooL WEB SITE

On AirPolTooL website aitpol.fatih.edu.tr, Istanbul air pollution forecasts for today, tomorrow, the day after tomorrow are displayed (cf. **Figure 4**). A menu bar (see section 1 on **Figure 4**) gives information and support to users. By clicking over an area located on the map section (see section 3) small yellow circles, it is possible to view the forecasts (see section 5) for the selected area and at the same time it is possible to get current meteorological data for selected area (see section 2). When an area is selected, as default, forecasted SO_2 values appear on the screen. Alternatively, in order to see the forecasts of other pollutants (CO and PM_{10}); the pollutant should be selected from pull down menu (see section 4) at the middle right side.

On Figure 5 are shown examples of simulated air pollution forecasts within red zone (3000 $\mu g/m^3$) for March 6, yellow zone (2000 $\mu g/m^3$) for March 5, and green zone (855 $\mu g/m^3$) for March 4.

A sample demonstration of the forecast results is shown on **Figure 6**. These results are from 03.03.2005 till 06.03.2005. The current day is 03.03.2005 and the simulated value is a measured value. The values of the following days (04.03., 05.03. and 06.03.) are predicted values.

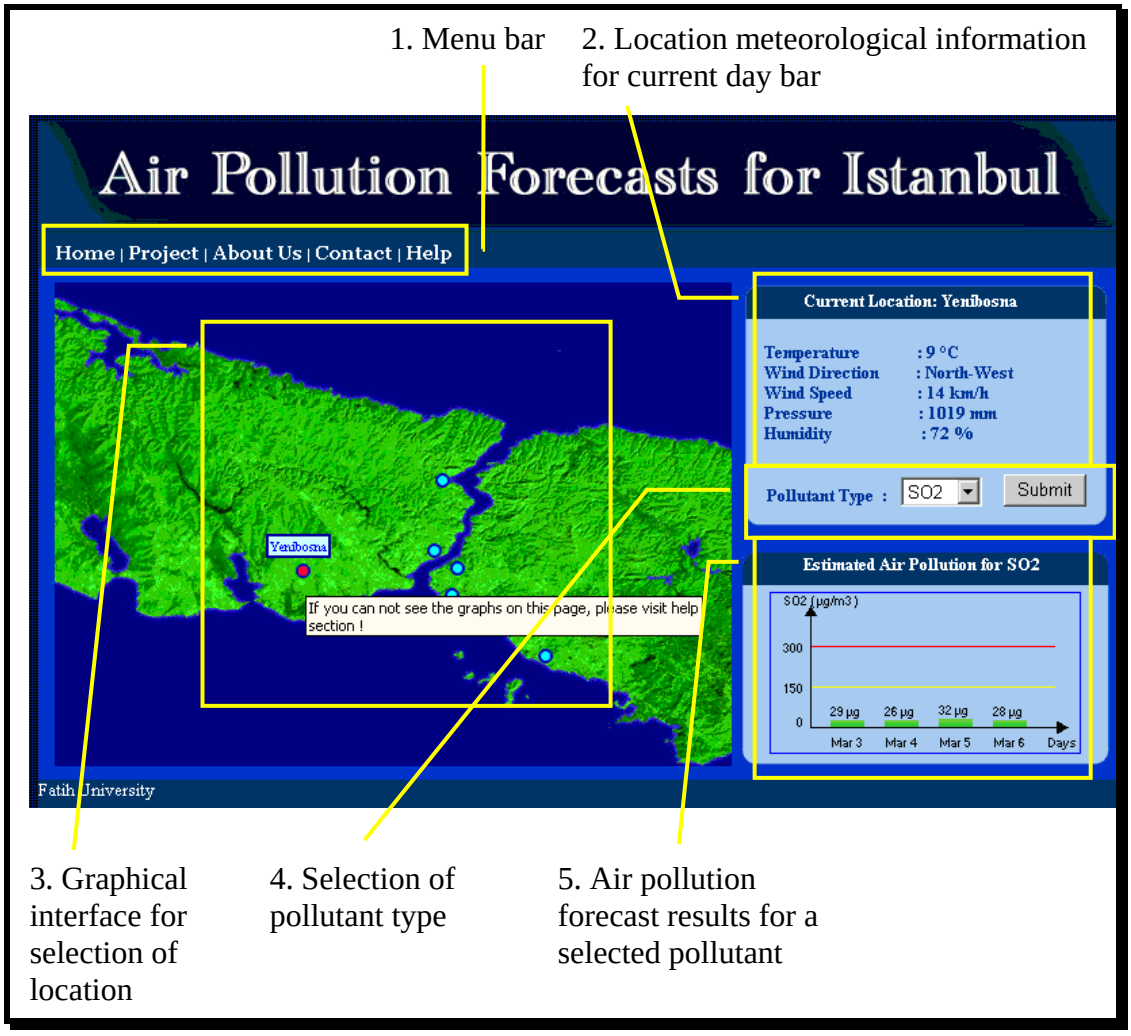

Figure 4. User interface of the web site

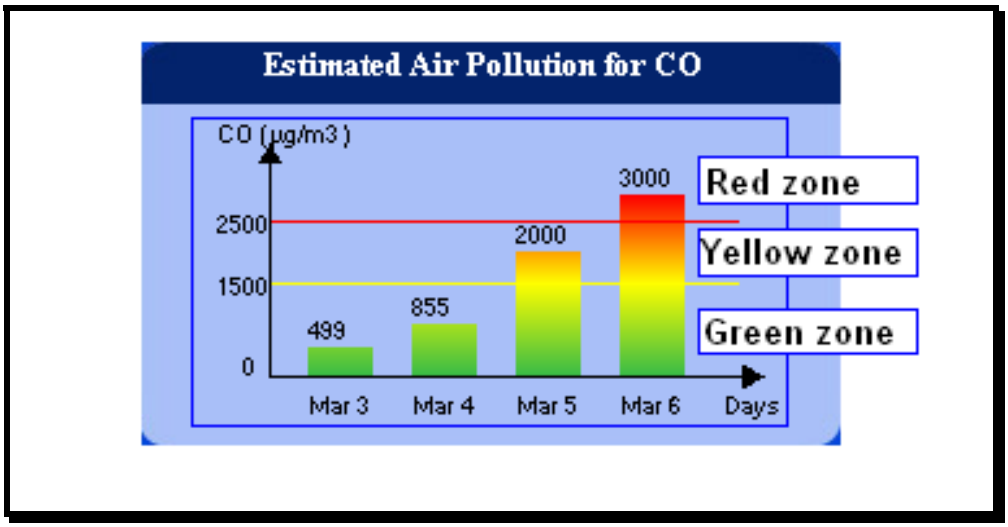

Figure 5. Presentation of pollution levels

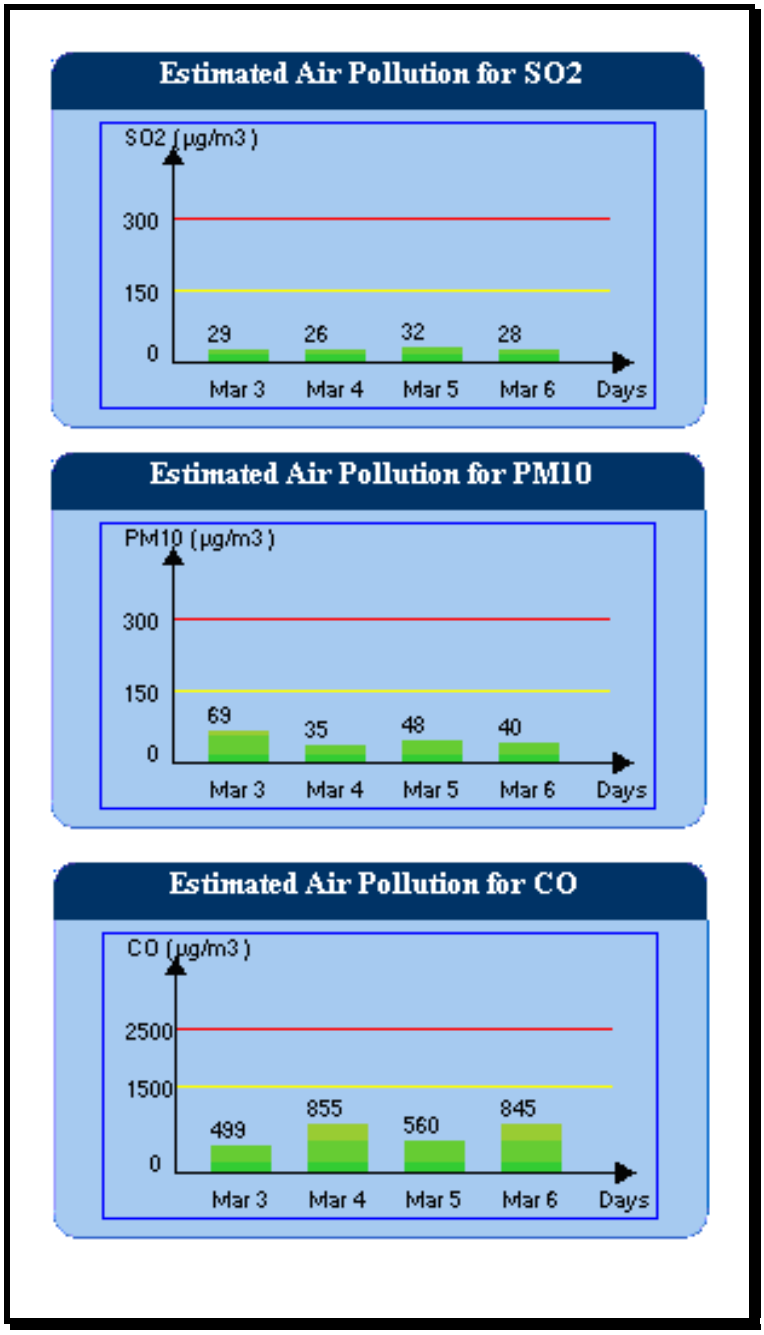

Figure 6. Forecasted results for SO_2, PM_{10} and CO on March 4-5-6

4. CONCLUSION

A web-based tool AirPolTool for air pollution evaluation and control in Istanbul is developed. The most popular neural networks, the backpropagation algorithms, were used to model the relationship between local meteorological data and air pollution indicators concentrations SO_2, PM_{10} and CO. AirPolTool is a user-friendly website for prediction of air pollutants in a metropolitan city like Istanbul. It offers appropriate episode warning signals and the relevant actions to be taken by the government or the public to reduce that particular pollutant to non-harmful level.

The application-oriented outcomes of this study are:

1. Website for Istanbul air pollution forecasting http://airpol.fatih.edu.tr;

2. Map presentation and visualization of air pollution predicted data;

3. Supporting of proper actions and warnings; like fuel curtailment or old people and children warning.

Further developments:

- A more detailed (up to 11 parameters) weather data can be retrieved from www.weather.com which provides a web service (see Web Services, 2005) to retrieve data in XML format. In the next version of the program we plan to this web service to provide a better estimate of air quality.
- For providing a web service to concerned parties that can estimate air quality for Istanbul. Web service applications such as early warning and control systems can be developed.
- The website will also provide a query form for past data by choosing a past date. The estimated and real values along with error rates will be shown.

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